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USING DIGITAL ELEVATION MODEL IN GEOMORPHOLOGY IN THE CASE OF THE VELENCE MOUNTAINS

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Introduction

Using sophisticated GIS software makes easier the investigations of geographical processes and offers a new approach to problems. However publications about geomorphologic problems and processes solved by GIS software and database still come out occasionally (*Telbisz, 1999*).

Below are presented some case studies of using digital elevation model in geomorphologic processes. Our primary goal is to prove some part from the landscape evolutional processes presented in the following chapter, therefore we could prove that using GIS methods in morphogenetic investigations is a correct method.

Short summary of landform evolution in the studied area

Several works has already been published about geology and structure of Velence Hills. Explorers of the area, like Vendl (*1911*), Jantsky (*1957*), Vadász (*1960*) agree that the small upland originated from the Palaeozoic, and is a well-defined and fractured remnant of a Caledonian – Hercinian piece of orogen.

After consolidation fractures and splits had dissected the granite on NE-SW direction as a result of different tectonic events. The axis of cracks is parallel with the strike of the hills itself, later cracks and slips developed perpendicularly to this direction, thus orientating the later developed valleys. Traces of Eocene volcanic activity, confined to Upper-Cretaceous orogenic movements in the form, andesite lava can be found in some places mainly on the NE part. Beside of this, remains of Tertiary are Pannonian sediments (sandstone), superimposing directly the basement. Regolith accumulated on the hillslope, deluvial loess and different alluvial sediments form the Quaternary.

Landform evolution and geomorphological feature of the area are described mainly in the essays of Bulla (*1962*) and Ádám (*1988, 1993, Fig. 1*). The small hill dissected to horsts and peneplain under tropical climate during Mesozoic and by Tertiary it had turned into an undulating with low energy of relief (*Bulla, 1962*). Remnants of Eocene volcanism also became removed the prevailing then by erosional processes. Volcanic rocks survived only in the form of necks and secondary volcanic cones. Triggered by tectonic events, related to volcanism, the former consolidated granite segmented into blocks. Subsequently the peneplanisation had continued, which is proofed by the missing Oligocene and Miocene sediments. This process could be the most intensive in the Badenian age. Under subtropical, humid climate, a thick regolith mantle accumulated down to the fresh granite, which had been eroded continuously. This way a slightly undulating secondary peneplain surface. Then, beneath the thick regolith cover, cryptogenetic landforms such as could develop from the isolated fresh granite blocks. At the Sarmatian-Pannonian boundary, the northern part of the hill was dismembered mildly and was transformed into pediment (*Ádám, 1993*). During the Upper Pannonian the whole part of the hills were covered by water. After post Pannonian regression, pedimentation started again. Messinian, upper most stage of Miocene (6.5 – 5 M years ago), might have provided an ideal climate for pedimentation processes. Pannonian sediments were so thick, that it could not be eroded totally from the pediments formed earlier. Therefore in the north, there are covered fossil pediments.

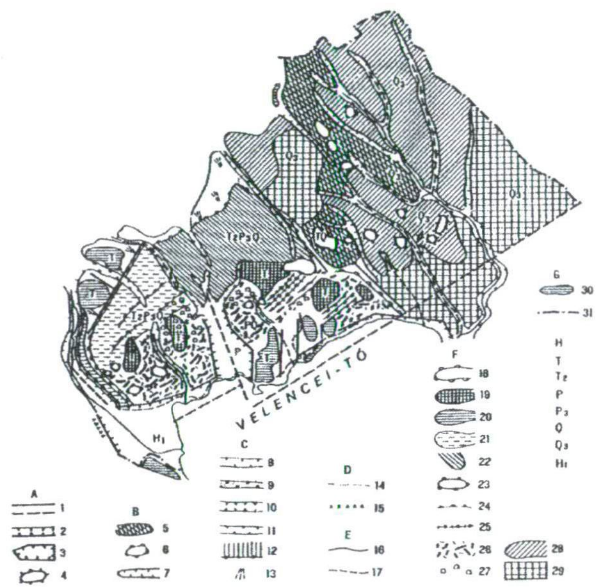

Figure 1 The geomorphological map of the Velence Mountains (by L. ÁDÁM).
A = Exogenous landforms: 1 = fracture line; 2 = trench by faulting; 3 = tectonic basin; 4 = secondary volcanic cone; B = Derasion forms: 5 = derasional ridge of hill; 6 = derasional monadrock; 7 = derasional valley; C = Erosional forms: 8 = erosion valley undifferentiated; 9 = erosion valley with flat floor; 10 = erosion valley with high gradient; 11 = erosional ravine; 12 = New Pleistocene terrace (II a, II b); 13 = debris form of slope washed; D = Lacustric abrasion forms: 14 = primeval shore (showing the highest former level); 15 = fossil abrasional platform; E = Hydrography: 16 = permanent watercourse; 17 = contemporary watercourse; F = Formations with complex genesis: 18 = planated block mountains; 19 = uplifted peneplain remains; 20 = subsided and exhumed peneplain remains; 21 = exhumed fossil pediment surface; 22 = covered fossil pediment surface; 23 = granite monadrock; 24 = eroded stepped vein; 25 = eroded hogback; 26 = eroding peneplain remains under devastation, containing dips without an outlet and hogback, rock pool and monadrocks; 27 = woolsacks, piedestal rocks; 28 = erosional-derasional ridge of hills; 29 = loess plain; G = Antropogen forms: 30 = fishing pond; 31 = boundary of catchment area; H = The age of land forms: T = Tertiary formations undifferentiated; T_2 = Late Tertiary landforms; P = Pliocene landforms undifferentiated; P_3 = Upper Pliocene landforms; H = Early Holocene landforms; Q = Quaternary landforms undifferentiated; Q_3 = Upper Pleistocene landforms; H_1 = Late Holocene landforms

Other types of them are the exhumed, fossil pediments. The rest of the hills is constituted by granite hills at highest positions, uplifted or subsided exhumed remains of peneplaine, denuded steps and special eroded landforms of granite (*Ádám, 1988, 1993*).Ádám (*1988*) showed that there is a difference between the morphology of lesser and intensively beresited granite surfaces. Where corrosion processes degrading rocks, triggered by postmagmatic events, were the most intensive, dome granite backs, denuded ribs and steps of strata granite deposits and pseudokarstic granite plates, developed by biogene granite corrosion, appear. At places where there are quite fresh granite rocks with some biotite and less dykes, exhumed big corestones, sometimes in abundance formed by cryoplanation into breached granite boulder (*Ádám, 1993*). On slopes without loess cover, thick granite rubble has accumulated, felsenmeer formed of them by Pleistocene frost action (*Bulla, 1962*). Erosion of regolith and exhumation of fresh granite blocks have been characteristic processes up to now.

Making Digital Elevation Model

Main and intermediate contour lines have been digitised from topographical maps at of 1:10000 scale of the Velence Mountains. After the required editing and transformation the grid-based Digital Elevation Model (DEM) was interpolated with TOPOGRID module within Arc/Info. The used model-maker algorithm is among the best tools that provide digital terrain model (*Katona, 2000*).

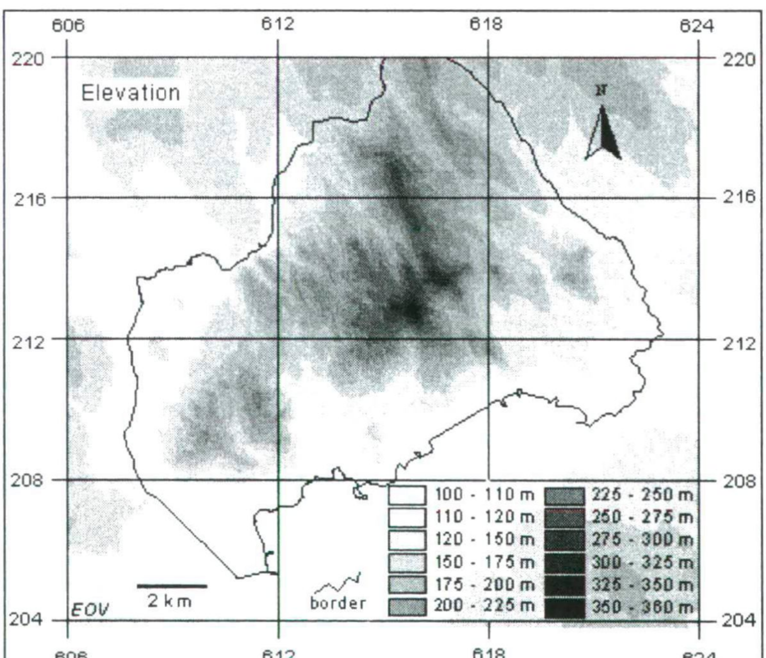

Figure 2 Digital Elevation Model of Velence Mountains

The cell size is 10 m which is a proper resolution in the given scale of the source maps (*Detrekői, 1994*).

Using DEM: the example of Velence-hills

An attempt was made to carry out geomorphological investigations with help of DEM at the following. Of course DEM analyses can only complete and document some parts of results, to be obtained by traditional geomorphological methods and perhaps they are suitable for setting up further direction of the letter. As we will see later DEM methods are usable at first for a purpose of demonstration, in fact they are computer aided and sophisticated variations of geomorphometric methods.

The ready elevation model (*Fig. 2*) could be used well to investigate slope categories, and expositions, energy of relief etc. The main aim of this work, however is not to deepen in different relief assessment investigations, so there is only a reference to it. About categories of slopes (tab. 1) are apparent that gentle slopes are typical of the area. Average energy of relief is lower (64 m/km^2: *Ádám, 1988*)) than that of the Vértes mountains in its neighbourhood. Presumably this is the result of the different geological-petrological structures of the two areas and the more repeated peneplanisation of Velence Hills.

The model is able to make relief profile between two selected points. Earlier Hungarian literature dealt with geomorphological analyses with help of constructed relief profiles (*Kertész, 1974, 1976*).

Angle of slopes	Area (percentage of the total)
0 – 2 degrees	43.1 km^2 (35.5 %)
2 – 5 degrees	38.6 km^2 (31.6 %)
5 – 10 deg.	27.7 km^2 (22.8 %)
Over 10”	12.3 km^2 (10.1 %)

Table 1 Slopes characters at Velence Hills

It has been assumed instead of superimposed profiles used by Kertész (*1976*) we illustrate the profiles one by one. It was practical to make the profiles parallel with the strike (SW-NE, fig. 3/A) and perpendicularly to it (NW-SE, fig. 3/C) with the affliction of the hills and of N-S and W-E direction (fig. 3/B, 3/C). Profiles made by this way allow some basic geomorphological investigations. Gradient of different sides demonstrate quite well that the batolit has tilted to S, SW direction (*Ádám, 1993*), that show the occurrence of steeper slopes tending to this direction. *Figure 3/A* shows well that Lapos valley sectioned SW and NE part of the hills confines to a downcast fault connected to one of the most characteristic fault line. More fractures and faults and presumably erosional valleys along them are discernible on the profiles. Higher features in the NE part (3/A) are former reported granite residual hills and secondary volcanic cones.

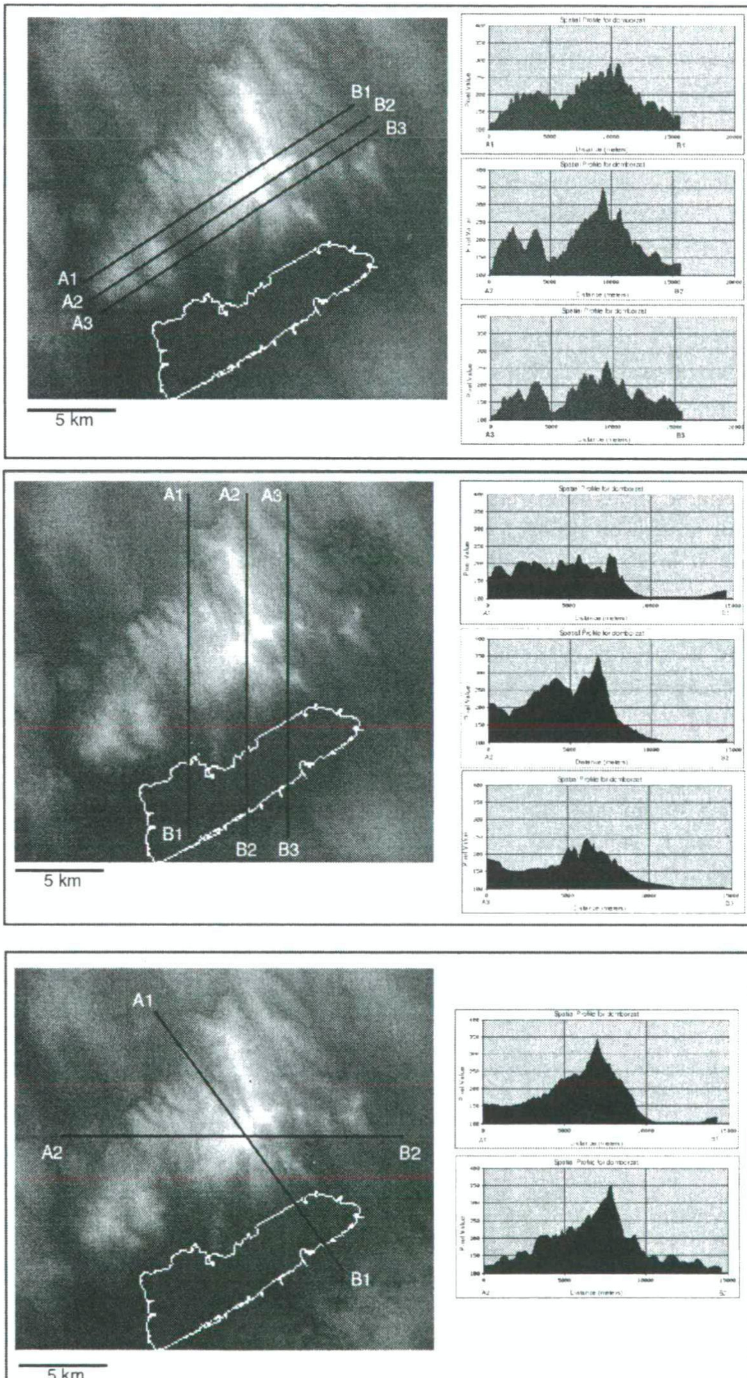

Figure 3 Profiles of the study area

There are not any frequent rises on the SE part. This area is poorer in these landforms, it is mainly exhumed peneplain and pediment (*Ádám 1993*). The break of the gradient on the southern slopes is important. It can be seen on each of the profiles and it may be a previous higher level of Lake Velence. Second profile of *fig. 3/C* shows an eastward link of the hills to Mezőföld plain with steeper slopes. This and first profile of *fig. 3/A* show the different erosion between granite and dykes and in consequence, the morphological and orographic differences. However it should be stressed that these profiles themselves can not proof, they just support the former written facts, reported by the literature.

The Velence-hills must be delineated inside the model for subsequent investigations. Orographical difference between pediments and the plains covered by loess, separated by flows can be recognised. Therefore we postulated that the limits of the hills water courses and bodies (Császár-water, Pátkai-reservoir, Fishlake, Rovákja-creek, Kender-lake, Veréb-Pázmándi-flows, Bágyom-creek, Lake Velence) which their primary catchment area is the Velence-hills itself. The following investigations have been made within the selected area (*fig. 2*) in such a way.

Altitude patterns in the area are shown on *fig. 4*. No exact consequences can be deduced but quite well defined variations of the distribution could show the boundaries of different relief levels. It seems that there are four relief levels in the hills and its area. The lowest of them is about 120-130 meters high. These are accumulation surfaces and belong to the foreland of the hills. It can be seen well on the diagram that these levels are the most spread ones. It does not mean that the separation of the hill and other areas would have been incorrect, because there, the eroded result of the hills accumulates here, and to change the drainage-based limit line of the Velence-hills on the model would not be useful. The next level is about up to 230 m, qualified by Ádám (*1993*) as exhumed or covered fossil pediments. This level can farther be subdivided to a lower and a higher level. By the prevalence of 200-m level of altitude it is assumed be the bounder between the two kinds of pediments, which could have been developed in different ages. From this level, a change in the distribution follows. Columns (*fig. 4*) belonging to higher levels drop approximately in a linear sequence; it may mean another relief part..

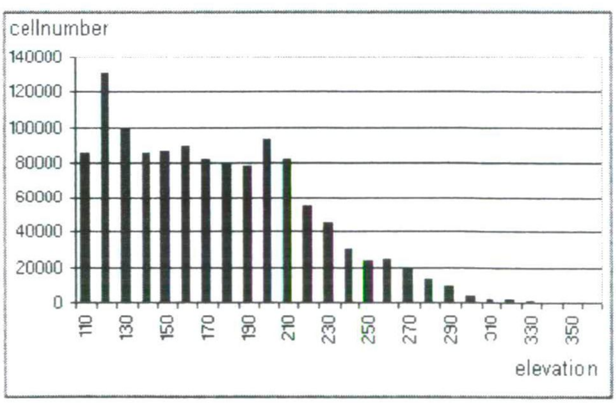

Figure 4 Distribution of the elevation values

It must be mentioned that this 200-m high level does not create a well-defined bounder. Over about 240 m, uplifted peneplains are the characteristic features, this adds the third relief level of the hills. The fourth level composed by the secondary volcanic cones and granite hills uplifted from peneplain. There is a quite great dispersion among the higher position of cones and plains. There are peneplains at higher positions and secondary cones at lower position

Figure 5 shows the map of relief selected by distribution of altitude levels. This shows well the settlements of prepared quartzite dykes, which are more resistant to erosional processes then those of granite.

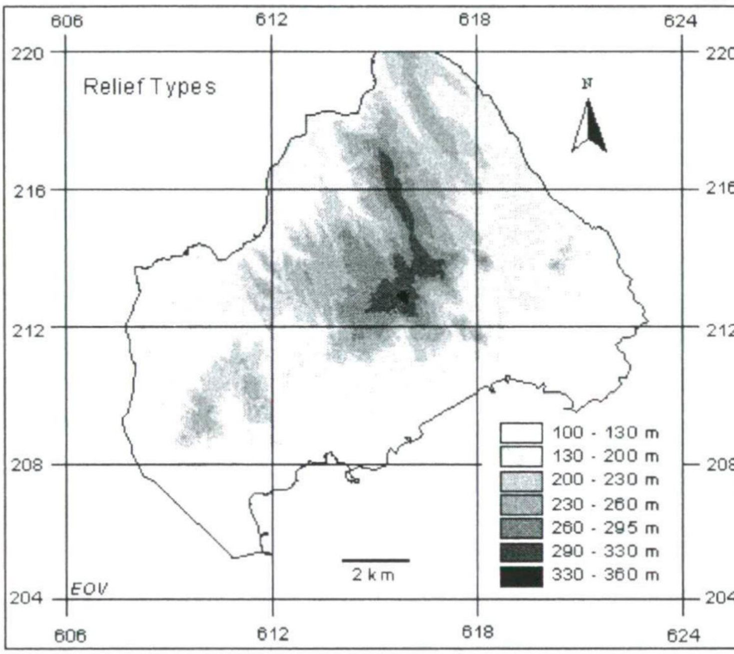

Figure 5 Map of selected relief types

Relief shading is a traditional method to present the surface. During making the screened map for reach parallel lights we presume a basis endless far, that lights our area. For this purpose a source of light is assumed illuminating the area from the infinite. Illuminate surfaces and those being in shadow are function of the angle and trend of slopes exclusively i.e. cast shadows are excluded. A well performed elevation model provides a spectacular and rapid "show" round the hill, after having calculated slope angles and exposures and given the position of the source from of light (azimuth and altitude). Two luminance maps (*fig. 6/A* north-west and *6/B* from north-east) are presented with the mass of the hills the dissected surface of granite and the secondary volcanic cones in the east.

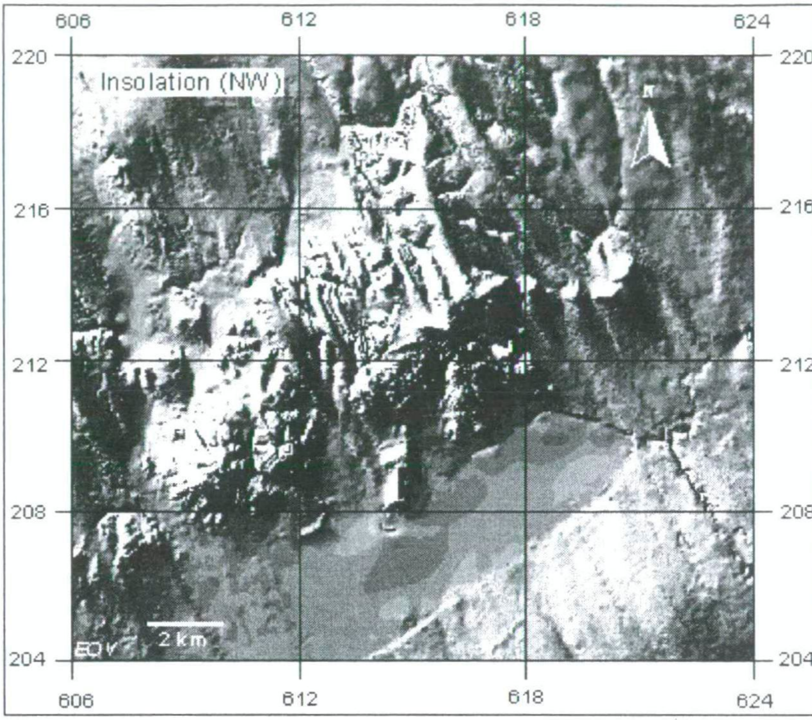

Figure 6/A Luminance-maps of the area (NW)

Conclusion

Among possibilities of using digital elevation models have been mentioned only a few methods. Analyses were made that could help in geomorphologic research. By help of used methods the tilting of batolith, dissection of granite, direction of fractures and valleys along them, were demonstrated. The main surface level of the hills has been selected, and it can be seen well on the map (*fig. 5*) that on the area is mainly occupied by pediments. Secondary volcanic cones and granite hills could be distinguished from peneplains. Orographical differences between granite rocks and dykes are discernible quite well. Luminance maps can be used to observe macroforms and main surfaces of the hills.

Geomorphological investigations using DEM has not ended with this study. The main aim of this publication was to show the capabilities of GIS methods in geomorphologic research.

Abstract

The essay was purposed to show some DEM methods in geomorphological investigations by the example of Velence-hills. Relief profiles, histograms showing the

distribution of altitudes, and the map with the main surface levels on the have proved some details of the geomorphologic evolution history of the area, described by former investigations. Relief screening is suitable to watch the main geomorphological features, valleys and their directions, macroforms etc. These methods presented by this essay give only an idea of the usability of GIS methods.

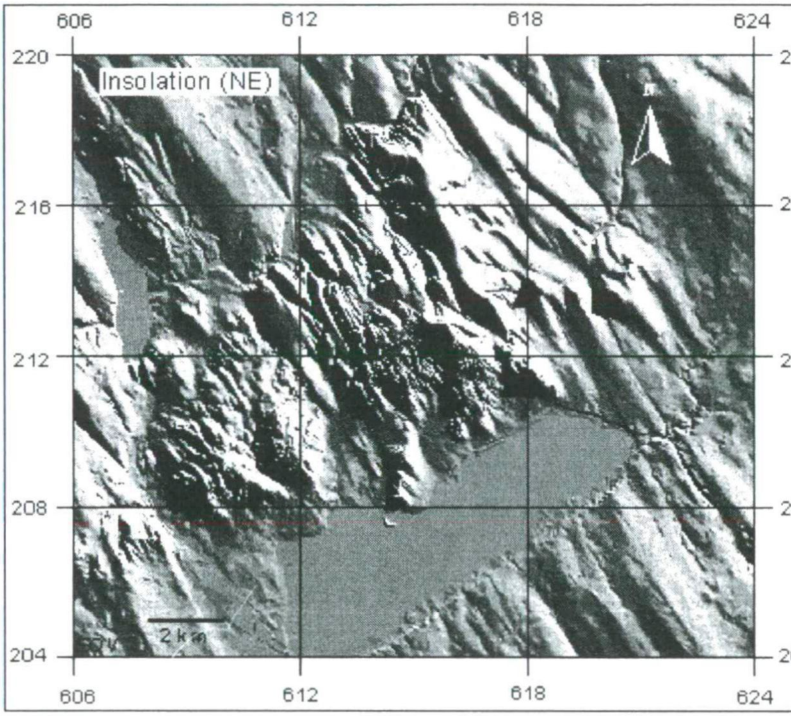

Figure 6/B Luminance-maps of the area (NE)

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